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Alaska Department of Fish and Game

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ABSTRACT

Coho salmon *Oncorhynchus kisutch* marked as juveniles with coded wire tags and adipose finclips in 1991 and 1992 were released into several freshwater systems of Northern Cook Inlet. Marked coho salmon were recovered in 1993 from commercial fisheries and escapements. Escapement samples were used to assess straying and the proportion of marked fish returning to each system. Commercial harvest data and recoveries of marked fish from the commercial harvest were used to estimate the harvest of stocked coho salmon from these systems in the Upper Cook Inlet commercial fisheries.

During the dates of the catch sampling program a total of 117,924, 39,333, and 61,870 coho salmon were harvested from the Central District drift net fishery, Central District Upper Subdistricts (eastside) set net fishery, and Northern District set net fishery, respectively. Coho salmon from the hatchery stocking programs contributed an estimated 8,922 fish (7.6%) to the Central District drift net fishery, 1,783 fish (4.5%) to the Central District eastside set net fishery, and 6,180 (10%) to the Northern District set net fishery.

Escapement counts of 382 coho salmon in Ship Creek and 2,376 coho salmon in Campbell Creek exceeded the biological escapement goal of 200 coho salmon in each stream. Estimates from the Statewide Harvest Survey show that effort and harvest increased in 1993 relative to the historic average at Campbell and Bird creeks, likely due to the return of stocked coho salmon, and remained at the same levels in Ship Creek. Recovery of 341 coho salmon with decodable tags from the escapement in Northern Cook Inlet streams indicated that hatchery-reared coho salmon did not stray into Campbell or Jim creeks or the Little Susitna River. Coho salmon stocked into Campbell Creek strayed into Ship Creek at a rate greater than 5%.

INTRODUCTION

Coho salmon *Oncorhynchus kisutch* are distributed throughout Upper Cook Inlet (UCI) and support the largest sport (Mills 1993) and the second largest commercial harvest (Meyer et al. *Unpublished*) in Alaska. Large, directed sport fisheries occur throughout UCI. In 1992, UCI contributed 55% of the statewide harvest and 80% of the southcentral sport harvest of coho salmon (Mills 1993). The largest sport fisheries for coho salmon occur on the Kenai, Susitna, and Little Susitna rivers. The primary commercial fisheries of coho salmon in UCI are the Central District drift gill net, the Central District Upper Subdistrict (eastside) set gill net, and the Northern District set gill net fisheries (Figure 1). Since 1966, the average harvest by fishery has been: drift (168,838 fish, 43%); Upper Subdistrict (45,677 fish, 15%); and Northern District (75,325 fish, 22%). Other set and drift gill net commercial fisheries compose the remaining 20% of the harvest.

The Northern Cook Inlet (NCI) urban area extends from Ingram Creek in Turnagain Arm north to the town of Houston (Figure 2). Recreational fishing effort in this area increased from an average of 178,000 angler-days from 1977 through 1985 to over 260,000 angler-days annually from 1986 through 1990 (Mills 1979-1991). Anglers fishing in the NCI urban area target five species of Pacific salmon *Oncorhynchus*, rainbow trout *O. mykiss*, Dolly Varden/Arctic char *Salvelinus malma*, and Arctic grayling *Thymallus arcticus*. Sport fisheries for these species are supported by both wild and hatchery-produced stocks.

As the population of the NCI urban area increases, the demand for sport fishing opportunities for anadromous salmon grows. Wild stocks are becoming fully utilized; therefore, as effort increases hatchery-produced stocks play an increasingly important role in supporting the growing sport fisheries. Stocking of anadromous fish has occurred in NCI since the 1970s, however, a successful fishery was not developed until the mid 1980s with the success of the chinook and coho salmon fisheries in Ship Creek. To increase recreational sport fishing opportunities in the NCI urban area, a coho salmon smolt stocking program was initiated in several NCI urban area streams in 1992. The guidelines for determining the success of this stocking program are that it be cost-effective, have minimal (if any) impact on other wild stocks or fisheries, and the sport harvest of these stocked fish will not compromise the historic levels of natural spawning escapement in the stocked streams.

The original urban stocking program involved stocking coho salmon smolt into seven NCI streams: Little Susitna River and Fish, Cottonwood, Wasilla, Ship, Campbell, and Bird creeks. Fish, Wasilla, and Cottonwood creeks were stocked with smolt raised at the Big Lake Hatchery, but this facility closed in July of 1993. The closure reduced the scope of this program, after 1993, to stocking smolt into the four remaining NCI streams. A portion of the smolt released in each stream were marked with an adipose finclip and coded wire tag, with a unique tag code used for each stream (Table 1, Peltz and Starkey 1993).

The stocking program should increase recreational angling opportunity and attract additional recreational fishing participation. The program is targeted to increase recreational angler effort by 20,000 angler-days and harvest by 10,000 coho salmon among all streams. Increases in recreational angler effort should result in increased economic benefit to the NCI urban

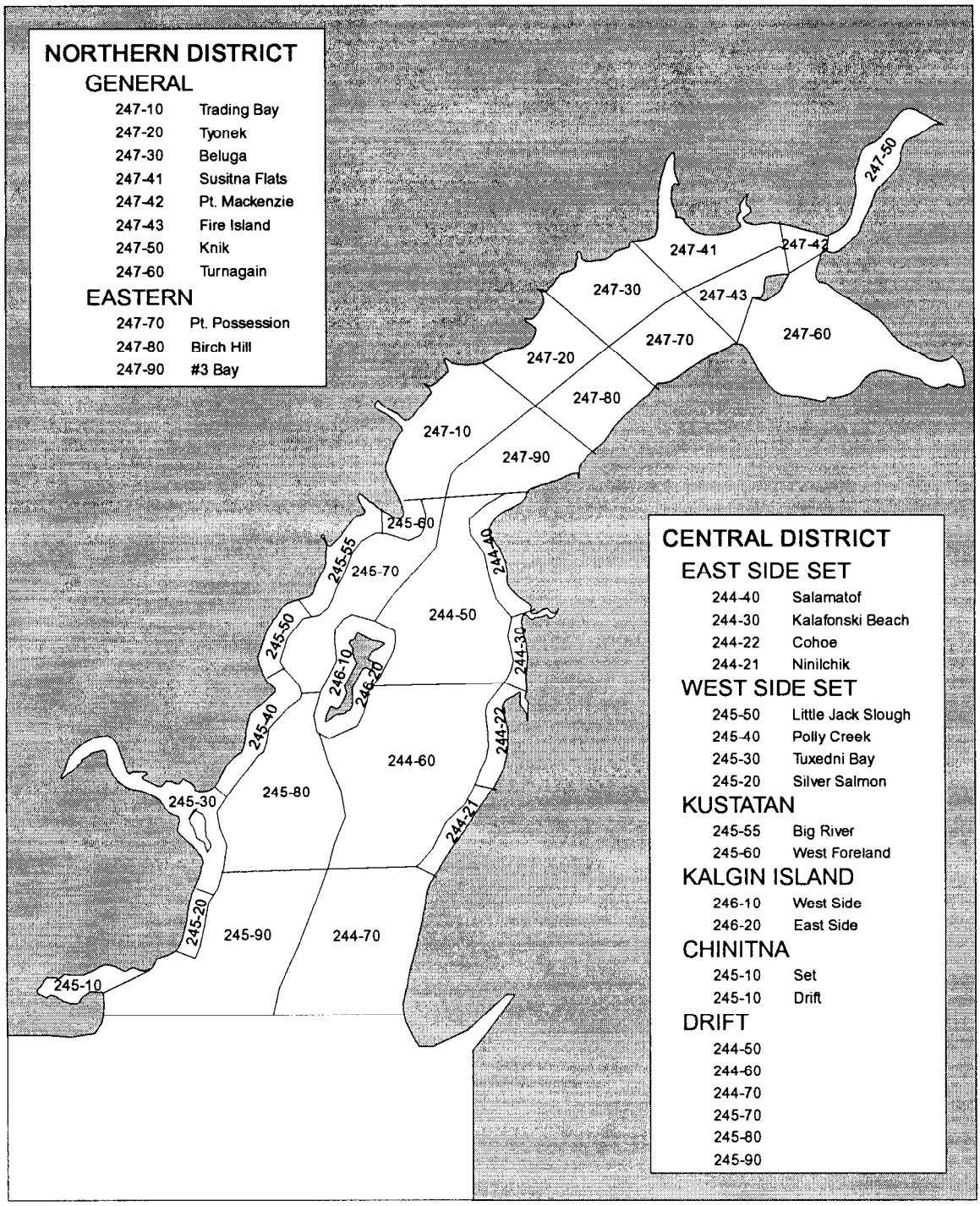


Figure 1. Map of Upper Cook Inlet commercial salmon fishing districts and statistical areas.

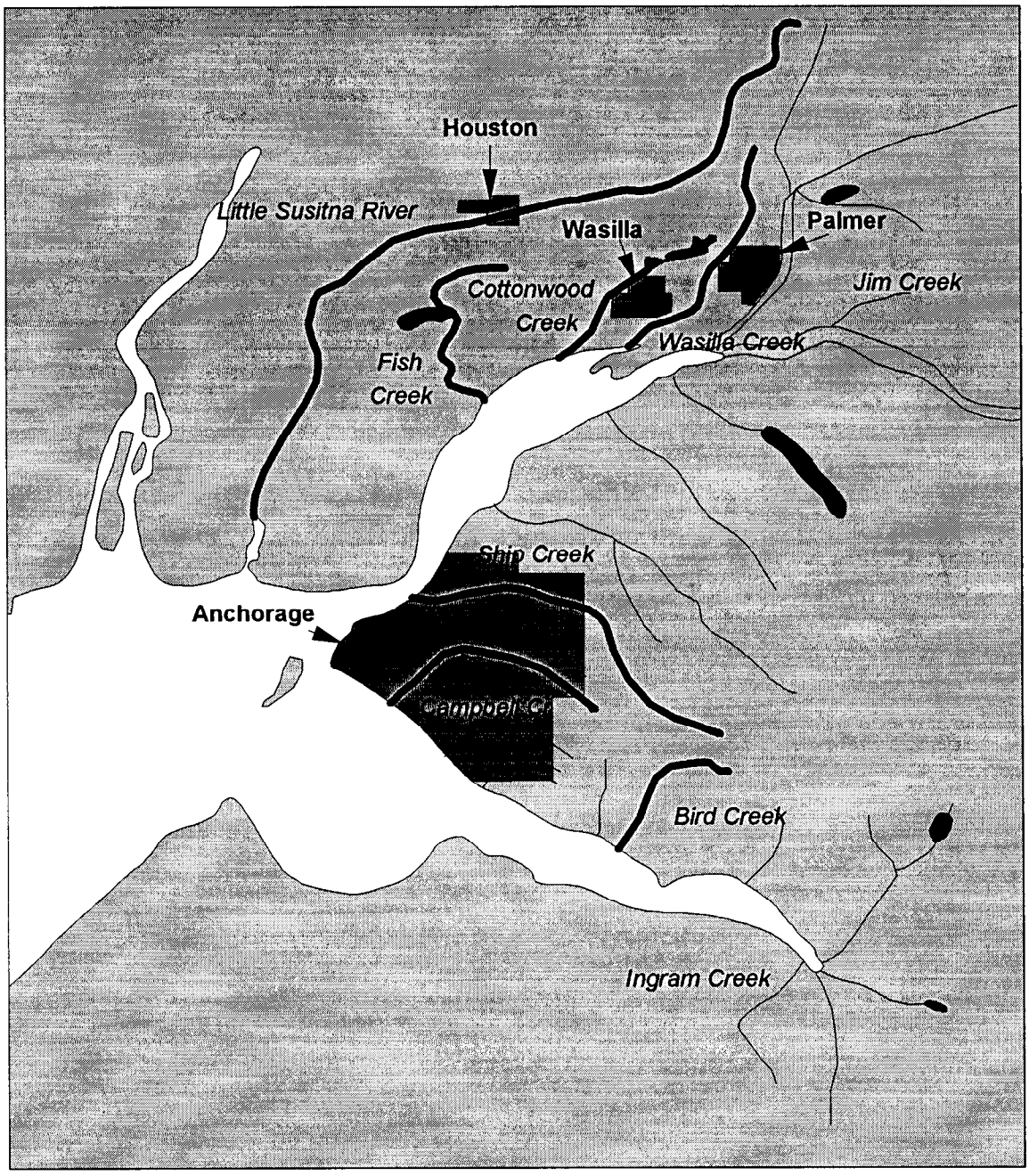


Figure 2. Map of Northern Cook Inlet urban areas.

Table 1. Summary of coded wire tagging data by release site for coho salmon reared at Big Lake, Elmendorf, and Fort Richardson hatcheries and stocked in Cook Inlet in 1992 (Peltz and Starkey 1993).

	Big Lake Hatchery			Elmendorf Hatchery	Fort Richardson Hatchery			
	Cottonwood Creek	Wasilla Creek	Fish Creek	Ship Creek	Houston	Nancy Lake	Bird Creek	Campbell Creek
Tag Codes	31-20-08 31-20-09	31-20-10 31-20-11	31-20-12 31-20-13	31-19-63 31-20-01	31-20-07	31-20-06	31-20-02 31-20-03	31-20-04 31-20-05
Total marked and tagged[a]	45,500	45,044	46,651	44,807	22,073	21,924	45,173	43,912
Mortalities[b]	10,159	896	1,113	721	189	326	270	231
Marked fish released	35,341	44,148	45,538	44,086	21,884	21,598	44,903	43,681
Tag retention sample size	1,890	1,786	1,798	1,723	842	934	1,684	1,717
Tag retention at release	93.2%	95.1%	95.8%	87.2%	89.4%	89.0%	83.8%	90.3%
Tagged fish released	32,938	41,985	43,625	38,443	19,564	19,222	37,629	39,444
Estimated total fish released[c]	53,900	76,315	74,953	67,178	154,466	158,459	95,377	97,076
Percent tagged	61.1%	55.0%	58.2%	57.2%	12.7%	12.1%	39.5%	40.6%
Tagging dates	3/4-20	4/3-15	3/20-4/3	1/29-2/7	2/27-3/9	2/25-27	3/9-13	3/16-19
Date of tag retention check	6/18	6/18	6/18	5/18-19	5/19-20	5/19-20	5/19-20	5/19-20
Days elapsed[d]	90	64	76	101	71	82	67	61

[a] Marked fish refers to fish with an adipose finclip and tagged fish refers to fish with an adipose finclip and a coded wire tag.

[b] An estimated 7,368 tagged smolt destined for Cottonwood Creek were not released due to their small size.

[c] The release number is the mark/recapture estimate.

[d] Days elapsed between the last day of tagging and the day tag retention was checked.

area. Estimates of sport angling effort and harvest from the Statewide Harvest Survey were used to evaluate the success of the NCI urban stocking program.

Despite the size and importance of UCI sport and commercial fisheries, no comprehensive program assessed the status of contributing stocks (Meyer et al. *Unpublished*). Coho salmon are harvested in commercial fisheries largely as a mixed-stock bycatch with no quantifiable information of stock origin. Large, directed sport fisheries of coho salmon occur throughout UCI. Estimates of harvest are available for many of these sport fisheries (Mills 1993), but there is no stock-specific information on the magnitude of total returns, exploitation rates, or spawning escapements.

An assessment program was developed by the Alaska Department of Fish and Game, Division of Sport Fish in 1991 to evaluate the coho salmon stocks of UCI (Meyer et al. *Unpublished*). This program was designed to estimate the harvest of selected wild and hatchery-reared coho salmon stocks to the commercial fishery in UCI and to evaluate the success of the hatchery coho salmon stocking programs in NCI. The overall program consists of five distinct but interrelated components: (1) the estimation of commercial harvest in UCI of stocked fish; (2) the marking of juvenile coho salmon and inriver recovery of marked adults, and estimation of the commercial harvest in UCI of wild stock coho salmon from the Kenai River; (3) the estimation of the sport harvest, enumeration of the escapement, and evaluation of the coho salmon stocking program in the Little Susitna River; (4) the enumeration of the escapement of coho salmon at Jim Creek; and (5) the production, marking and release of coho salmon smolt by the hatcheries. This report covers the first component above. Other components of the program are reported elsewhere (Carlon 1992; Carlon and Hasbrouck *In prep*; Bartlett 1994, *Unpublished*; Peltz and Starkey 1993).

OBJECTIVES

Objectives for the 1993 urban coho salmon assessment are divided into two groups, escapement and commercial catch sampling, as listed below.

Escapement

1. Enumerate the coho salmon spawning escapement through weirs at Campbell and Ship creeks and collect heads from adipose finclipped fish.

2. Test the null hypothesis that hatchery-produced coho salmon stocked in NCI streams do not stray from the stream of origin into Ship and Campbell creeks upon return.

Commercial Catch Assessment

3. Estimate the harvest of hatchery-produced coho salmon stocked in the NCI urban area streams in the Northern District set net fishery, the Central District Upper Subdistrict (eastside) set net fishery, and the Central District drift net fishery.

Data collected from other components of the overall UCI coho salmon assessment program are also pertinent to this project. In this report, estimates of the commercial harvest of coho salmon stocked in the Little Susitna River are presented. In addition, coho salmon were examined for adipose clips from the escapement and sport harvest in the Little Susitna River, and from the escapement passing the weir on Jim Creek. Coded wire tag data from these projects were used in this report to assess straying. The coho salmon hatchery stocking program at the Little Susitna River is evaluated in a separate project (Bartlett 1994). Data collected at Jim Creek was part of the coho and sockeye salmon assessment studies conducted by Bartlett (*Unpublished*).

METHODS

Study Design

The overall goal of the urban stocking program is to increase angler participation through increased opportunities to fish for coho salmon. The Statewide Harvest Survey is used to evaluate whether targeted increases in angler effort and harvest are achieved. However, if the returns are poor, then the cause of the poor returns must be determined.

Poor returns of adults to freshwater sport fishing areas could result from low smolt survival and/or high fishing mortality prior to reaching fresh water. This project estimates the harvest of hatchery-produced coho salmon stocks in the common property, mixed-stock commercial fishery and estimates the return of stocked fish to particular streams. Results should establish if returns are harvested prior to reaching the terminal areas. Data will also be provided to the hatchery stocking program to assess the impact of smolt production and release on the marine survival of smolt and on the abundance of the adult return.

The basic study design involved marking coho salmon smolt (or fingerling in some stockings in the Little Susitna River prior to 1992) with a coded wire tag and an adipose finclip. Marked fish were released with unmarked fish in 1992 and emigrated into marine waters. Catch sampling programs of adult coho salmon in the commercial harvest and the escapement were conducted in 1993 to recover marked fish. Heads were collected from clipped fish and sent to the Department of Fish and Game Coded Wire Tag Laboratory in Juneau (Tag Lab). The Tag Lab determined if a tag was present and decoded the tag number of fish retaining the tag. Catch sampling data were used to test assumptions of the model to estimate harvest and to determine the stratification necessary to provide an unbiased estimate of contribution with the best precision. Final estimates of contribution and their variances were then calculated.

Data Collection

Stocking and Marking:

Coho salmon from the Little Susitna River were reared at Ft. Richardson and Big Lake hatcheries. Coho salmon reared at Ft. Richardson Hatchery were stocked into Bird Creek, Campbell Creek, and the Little Susitna River at Houston and Nancy Lake in May 1992 (Peltz and Starkey 1993). Fish from Big Lake Hatchery were released into Cottonwood, Fish, and Wasilla creeks in

June 1992. Coho salmon reared in these hatcheries had also been stocked into Meadow Creek and Nancy Lake as fingerlings in 1990 and stocked into the Little Susitna River at Nancy Lake and Houston as smolt in 1991. Coho salmon from Ship Creek were reared at Elmendorf Hatchery and released as smolt into Ship Creek in May 1992.

The number of coho salmon stocked in 1992 as part of the NCI urban stocking program ranged from 53,900 at Cottonwood Creek to 97,100 at Campbell Creek (Table 1; Peltz and Starkey 1993). Approximately 155,000 were stocked at each location (Houston and Nancy Lake) of the Little Susitna River in 1992. Coho salmon were marked with a coded wire tag and adipose finclip from January to April 1992. The proportion of marked fish varied among hatcheries. Approximately 58% of each of the three release groups from Big Lake Hatchery and 57% of the coho salmon released from Elmendorf Hatchery were marked. At Fort Richardson Hatchery, 40% of the coho salmon released into Bird Creek and Campbell Creek and approximately 12% of the coho salmon released into the Little Susitna River at Houston and Nancy Lake were marked. Details of the rearing, marking, and release of hatchery stocked coho salmon are presented by Peltz and Starkey (1993).

Escapement:

Total counts of coho salmon above the inriver sport fishery were made on Ship and Campbell creeks from mid-July through mid-September 1993. A weir constructed on Campbell Creek near Folker Street and the live-box on the Ship Creek fish pass were used to enumerate fish migrating upstream. These weirs were operated 24 hours a day and all coho salmon were examined for missing adipose fins. Fish for brood stock were also collected at Ship Creek. A daily and cumulative count was made of all coho salmon passing these weirs and of coho salmon missing the adipose fin. Counts of other salmon species were also recorded. Escapement goals of 200 naturally spawning coho salmon have been established for both streams. To ensure the escapement goal was attained in both systems, only a portion of the coho salmon with an adipose clip were collected. Given the expected number of coho salmon in the escapement of each stream and the need to collect 60 coho salmon with coded wire tags from each stream to test the hypothesis of straying, heads were collected from every fourth finclipped fish at Campbell Creek and every eighth finclipped fish at Ship Creek. The heads of all finclipped coho salmon collected for brood stock at the Ship Creek weir were also collected. A uniquely numbered cinch strap was affixed to the head (jaw) and each head was placed in an individual clear plastic bag with the cinch strap number visible. Data recorded included: date, creek, number of coho salmon examined, number of coho salmon missing the adipose fin, and the cinch strap number of each head collected. All heads with cinch straps were returned to the Anchorage ADF&G office and frozen until shipment to the Tag Lab. The dam in Ship Creek was observed during peak high tides because of concern that coho salmon may get over the dam during these times.

Weirs were also constructed on the Little Susitna River (Bartlett 1994) and Jim Creek (Bartlett *Unpublished*) to enumerate the escapement and examine coho salmon for missing adipose fins. No coho salmon were stocked in Jim Creek so no marked fish were expected to be observed in the return.

Commercial Catch Sampling:

Catch sampling of the UCI coho salmon harvest was conducted from mid-July to mid-September 1993 when the majority of the coho salmon harvest occurred. Coho salmon were usually sampled at processors, on sorting lines or from totes, but at times were sampled aboard tenders or at buying stations. All regular commercial fishing periods (7:00 a.m. to 7:00 p.m., Mondays and Fridays) were sampled. Additional fishing periods were sampled as time and budget allowed. There were no extra periods in the Northern District or the Central District Upper Subdistricts set net fisheries after 15 August.

Coho salmon delivered to the processors were enumerated using tally-whackers and examined for the absence of adipose fins. As many fish as possible were examined from deliveries during the sampling shift. All adipose finclipped coho salmon observed were retrieved, the head removed, and a uniquely numbered cinch strap affixed to the head. Processors usually wanted to record the total weight of all fish delivered, therefore, finclipped coho salmon were weighed before the head was collected. Each head was placed in an individual clear plastic bag with the cinch strap number visible.

Data recorded included the date, processor, delivery, statistical area, number of coho salmon examined, number of coho salmon missing the adipose fin, number of heads collected from coho salmon missing the adipose fin, and the cinch strap number of each head collected. All coho salmon heads with cinch straps were returned to the ADF&G offices in Soldotna or Anchorage. The heads were frozen immediately and shipped each week to the Tag Lab to remove and decode the tags. After each commercial fishing period, the total commercial harvest of coho salmon for UCI by statistical area was obtained from the Division of Commercial Fisheries Management and Development (CFMD) in Soldotna. Final harvest data for the season were obtained approximately 2 months after the commercial season ended.

In general, totes sampled from set net harvested coho salmon were pure loads of fish harvested from a single statistical area. Totes of coho salmon sampled from the Central District drift net fishery were a mixture of fish harvested in different statistical areas. Total number of coho salmon harvested and the number of harvested coho salmon purchased by each processor by date and statistical area were retrieved from the CFMD fish ticket database on 2 March 1994. Thus, for samples from set net harvested coho salmon we knew the total harvest by statistical area and date. For each date-statistical area-processor combination, the number of harvested coho salmon purchased, the number examined, and the number with a missing adipose fin were also known. We had the same data for coho salmon harvested in the Central District drift net fishery except the harvest and number purchased were the sums of statistical areas 244-50, 244-60, 244-70, 245-70, 245-80, and 245-90.

Northern District. Catches processed in the Anchorage area during 1993 were comprised entirely of Northern District fish, with sampling effort initially concentrated at two processors: Whitney Foods and Laona Processing. Cook Inlet Processors (CIP) in Nikiski was sampled regularly for set net harvest from statistical areas 247-70, 247-80, and 247-90 by personnel from Anchorage through mid-August and by technicians from Soldotna through September. Sampling was also conducted at the Icicle plant in Homer for two periods in mid-August. Inseason changes in buying patterns in the Anchorage area (Laona

closed) lead to the sampling of two additional processors in Anchorage, Great Pacific and Sahalee. Additional catch sampling was periodically conducted onboard tenders. Technicians contacted the processors throughout the season to coordinate sampling logistics and to ensure that all possible fish were examined.

The Northern District catch sampling in Anchorage was conducted from 16 July through 20 August when all processors closed for the season. Sampling was conducted at the CIP plant in Nikiski until 13 September.

Central District. Commercial catch sampling in the Soldotna area included harvests from the drift net, the Upper Subdistrict set net, and the aforementioned Northern District set net fisheries. Sampling was conducted at several fish processing facilities under the supervision of the CFMD biologists. Sampling of the drift net harvest was concentrated at Wards Cove Packing, Inlet Salmon, Kenai Packers, Salamatof Seafoods, Dragnet Fisheries, and Trans-Aqua International. The Upper Subdistrict set net harvest was sampled by contacting buying stations for the major fish processing plants in the Soldotna/Kenai area including: Carlson Seafoods, Cook Inlet Processing, Dragnet Fisheries, Icicle Seafoods, Inlet Fisheries, Keener Packing, Kenai Packers, Royal Pacific Fisheries, Salamatof Seafoods, Trans-Aqua International, and Wards Cove Packing.

The Central District drift net fishery was sampled by six port samplers from 9 July through 30 August. The Upper Subdistrict set net fishery was sampled by four port samplers from 23 July through 30 August.

Data Analysis

Straying:

There were concerns that coho salmon released as part of the urban stocking program would not adequately imprint to the release stream and might stray into a different stream upon return. A chi-squared statistic was used to test the hypothesis that stocked coho salmon stray from the stream of stocking upon return such that a stray rate of 0.05 could be detected 95% of the time at $\beta = 0.05$. Only recoveries from the adult escapement at Ship and Campbell creeks were used for this test. Coho salmon were also sampled in the escapement at the Little Susitna River and Jim Creek (Bartlett 1994, *Unpublished*).

The number of coho salmon recovered at the weirs on Ship and Campbell creeks with coded wire tags which where not stocked in these respective systems were used to test the hypothesis regarding straying. If all 60 tagged coho salmon recovered at the weir were originally stocked in that creek, then straying rate was likely < 5%. If one or more of the 60 coho salmon was originally stocked in a different creek, then straying rate was likely ≥ 5%.

Estimating Commercial Harvest of Stocked Coho Salmon:

Estimating the harvest of a cohort of fish in a commercial fishery required estimating the proportion of marked fish. The proportion of tagged coho salmon stocked at each location was determined prior to release and was treated as a known constant (Peltz and Starkey 1993). However, if significant

tag loss occurred after release, then the proportion of tagged coho salmon was estimated by sampling the inriver return of adults.

A chi-squared statistic was used to test if the tag retention of adults was the same as that of release. To conduct the test, only adult recovery data from the escapement at Campbell and Ship creeks and the Little Susitna River were used. Release data from Houston and Nancy Lake were pooled to get an overall estimate of tag retention at release of fish stocked into the Little Susitna River.

Harvest of a single cohort (release group) of fish in a stratum was estimated by (Clark and Bernard 1987):

$$\hat{n}_1 = \frac{m_1 a_1 N m_c}{m_2 a_2 n_2 \theta} \tag{1}$$

where:

m_1 = number of heads with coded wire tags detected,

m_2 = number of coded wire tags found and decoded,

a_1 = number of heads collected in the sample from fish with a missing adipose fin,

a_2 = number of heads that arrived at the Tag Lab,

N = total number of fish in the harvest,

n_2 = number of fish in the harvest examined for a missing adipose fin,

m_c = number of decoded coded wire tags from the cohort, and

θ = proportion of the cohort marked and released with coded wire tags.

This estimator is statistically unbiased when sampling is from a simple random or pseudo-random process (Clark and Bernard 1987). When the harvest (N) and the proportion marked (θ) are known without error an unbiased estimate of the variance is:

$$V(\hat{n}_1) = \left[\left(\frac{m_2}{m_2 - 1}\right)\left(\frac{m_1 - 1}{m_1}\right)\left(\frac{a_2}{a_2 - 1}\right)\left(\frac{a_1 - 1}{a_1}\right)\left(\frac{n_2}{n_2 - 1}\right)\left(\frac{N - 1}{N}\right)\right]\left[m_c\left(\frac{N m_1 a_1}{m_2 a_2 n_2 \theta}\right)^2\right] \times \left[1 - m_c + \left(\frac{(m_2 - 1)(a_2 - 1)(n_2 - 1)}{(m_1 - 1)(a_1 - 1)(N - 1)}\right)\left(\frac{m_1 a_1 N m_c}{m_2 a_2 n_2} - \theta\right)\right]. \tag{2}$$

Values of harvest from the fish ticket database are assumed known and measured without error. We found no significant difference in tag retention (Table 2) between release from the hatchery and adult escapement samples[1] at Campbell Creek ($\chi^2 = 0.35$, df = 1, P = 0.55), Ship Creek ($\chi^2 = 2.21$, df = 1, P = 0.14), or the 1992 smolt releases into the Little Susitna River ($\chi^2 = 0.18$, df = 1,

[1] Although not significantly different, point estimates of tag retention as adults were always less than those at release. This comparison should continue to be investigated.

Table 2. Number sampled (n) and percent retention (%) for coded wire tagged coho salmon at release and recovery in the escapement of Northern Cook Inlet streams, 1993.

System	Release[a]		Recovery Escapement	
	n	%	n	%
Ship Creek	1,723	87	44	80
Campbell Creek	1,717	90	161	89
Bird Creek	1,674	84	-[b]	-
Little Susitna River	1,776	89	177	88

[a] Data from Peltz and Starkey 1993.

[b] No escapement data collected from Bird Creek.

P = 0.67). Therefore, values of θ at the time of release (Peltz and Starkey 1993) were used and treated as known values measured without error.

Harvest of each cohort was stratified by date and statistical area for each fishery. Statistical area was unknown when catch sampling the Central District drift net fishery, so harvest of this fishery was stratified only by date. The total harvest of a cohort in a fishery was estimated by summing the estimates among the strata. Variance of the total estimate was also calculated by summing the variances of the strata estimates since strata were assumed independent and there were no additional covariance terms.

We investigated whether data could be pooled among dates within each fishery and among statistical areas of set net harvested coho salmon. Total harvest and its variance were estimated with the data stratified and with the data pooled. For example, to determine if two statistical areas could be pooled, estimates were calculated with the data stratified by statistical area and then calculated with data from the two statistical areas combined. If the estimates of harvest were not significantly different and pooling the data improved the precision of the estimate, the data were pooled. Otherwise, estimates were stratified.

We also examined if the data should be further stratified by processor. We calculated a series of chi-square statistics to test the hypothesis that the marked:unmarked ratio (i.e. the number of coho salmon with coded wire tags from a cohort to the total number of coho salmon examined for adipose clips) was not different among processors purchasing coho salmon in the different fisheries. Although some differences were found among processors, the proportion marked generally ranged only between 0.005-0.05 for predominant cohorts among all processors in all fisheries. We concluded these differences were too small to seriously bias the estimates and pooled catch sampling data among processors.

RESULTS

Escapement

The escapement at Campbell Creek was at least 2,376 coho salmon, including 673 fish with an adipose clip (Appendix A). This was a minimum count because the weir was removed before coho salmon finished migrating. High water and excessive debris in the river necessitated the early removal of the weir. A total of 161 heads were collected and shipped to the Tag Lab (Table 3). The escapement count on Ship Creek was 382 fish with 128 of those being adipose clipped. The Ship Creek weir was operated for the entire coho salmon run. A total of 44 heads were recovered and sent to the Tag Lab. Examination of coho salmon for missing adipose fins on other projects yielded 177, 7, and 0 heads from the Little Susitna River, Fish Creek, and Jim Creek, respectively (Table 3). There were 341 coded wire tags decoded from the 389 heads recovered from all weirs.

The contribution of hatchery fish to the escapement was calculated from tag recovery data for Campbell and Ship creeks. In Ship Creek, an estimated 202 (53%, SE = 31) of the 382 fish in the escapement were of hatchery origin, 153 (SE = 17) of those were from fish stocked in Ship Creek and 49 (SE = 26) were

Table 3. Summary of sampling efforts and escapement counts of coho salmon at weirs in systems in Northern Cook Inlet, 1993.

	Number to Weir	Number Examined	Number of Adipose Clips	Number of Heads Collected	Number of Decodable Tags	Total Passing Weir	Dates of Operation
Ship Creek[a]	382	382	128	44	35	338	7/29 - 11/3
Campbell Creek	2,376	2,376	673	161	143	2,215	7/29 - 9/16
Little Susitna R[b]	34,999	4,860	187	177	156	34,822	7/23 - 9/12
Fish Creek[c]	2,071	347	8	7	7	2,078	7/08 - 8/20
Jim Creek[d]	5,532	1,518	0	0	0	5,532	7/16 - 9/12
Totals			996	389	341		

[a] Twenty-eight of the 44 heads collected in Ship Creek were collected during harvest of brood stock.

[b] Bartlett 1994

[c] The weir at Fish Creek is operated to enumerate sockeye salmon, therefore counts of coho salmon do not represent the entire run (Larry Peltz, Alaska Department of Fish and Game, Palmer, personal communication).

[d] Bartlett *Unpublished*.

from other stocking locations. In Campbell Creek 1,658 of the 2,376 fish (68%) in the escapement were of hatchery origin. Because all coho salmon in the escapement at Campbell Creek were examined for marks and all marked fish recovered were from the Campbell Creek release, no variance was calculated for the contribution of hatchery-produced coho salmon to the escapement.

Straying

A total of 341 decodable tags were recovered from random samples of the escapements at Ship, Campbell, Jim, and Fish creeks, and the Little Susitna River (Table 4). In Campbell and Fish creeks and the Little Susitna River all of the tags recovered were from fish stocked in that same stream. There was significant straying ($P = 0.03$, Fisher's exact test) of Campbell Creek fish into Ship Creek. Two of 35 tagged coho salmon recovered in the escapement at Ship Creek were originally released into Campbell Creek. From the escapement of 5,532 coho salmon at Jim Creek a total of 1,518 (27%) fish were examined for missing adipose clips (Bartlett *Unpublished*). No adipose clipped fish were observed in this sample. In addition, of the 507 tags recovered from the Kenai River sport harvest, one tag was from a coho salmon stocked at Ship Creek (Carlon and Hasbrouck *In prep*).

Returns

Total returns of coho salmon to urban area streams are made up of three measurable components: spawning escapement, commercial harvest, and inriver harvest. The spawning escapement and estimates of commercial harvest are presented in this report. Total inriver harvest was estimated through the Statewide Harvest Survey program (Mills 1994). Most of the returns to Ship, Bird, and Campbell creeks were harvested by the sport fishery (Figure 3).

Inseason observations of the sport fishery at the Anchorage urban streams indicated that the coho salmon stocking program exceeded expectations. As a new fishery, Campbell Creek supported a large increase in participation, and participation levels at Bird and Ship creeks also appeared to increase. Statewide Harvest Survey estimates (Mills 1994) indicated that effort at Campbell Creek increased from 1,500 angler-days in 1992 to over 9,000 in 1993, and effort at Bird Creek increased by 1,000 angler-days to 12,000 (Figure 4). Harvest estimates indicate that approximately 4,000 coho salmon were harvested at Campbell Creek, and over 6,000 were harvested at Bird Creek. Ship Creek effort did not increase appreciably, but harvest increased by nearly 35% to 2,500 coho salmon.

Commercial Harvest of Stocked Coho Salmon

A total of 271,118 coho salmon was harvested by the Central District drift net, the Central District eastside set net, and the Northern District set net commercial fisheries in 1993 (Table 5). Catch sampling did not occur over the entire fishing season, and one statistical area in the Northern District, 247-30, was not sampled. A total of 219,127 coho salmon were harvested during the times and from the statistical areas sampled in 1993 (Table 6).

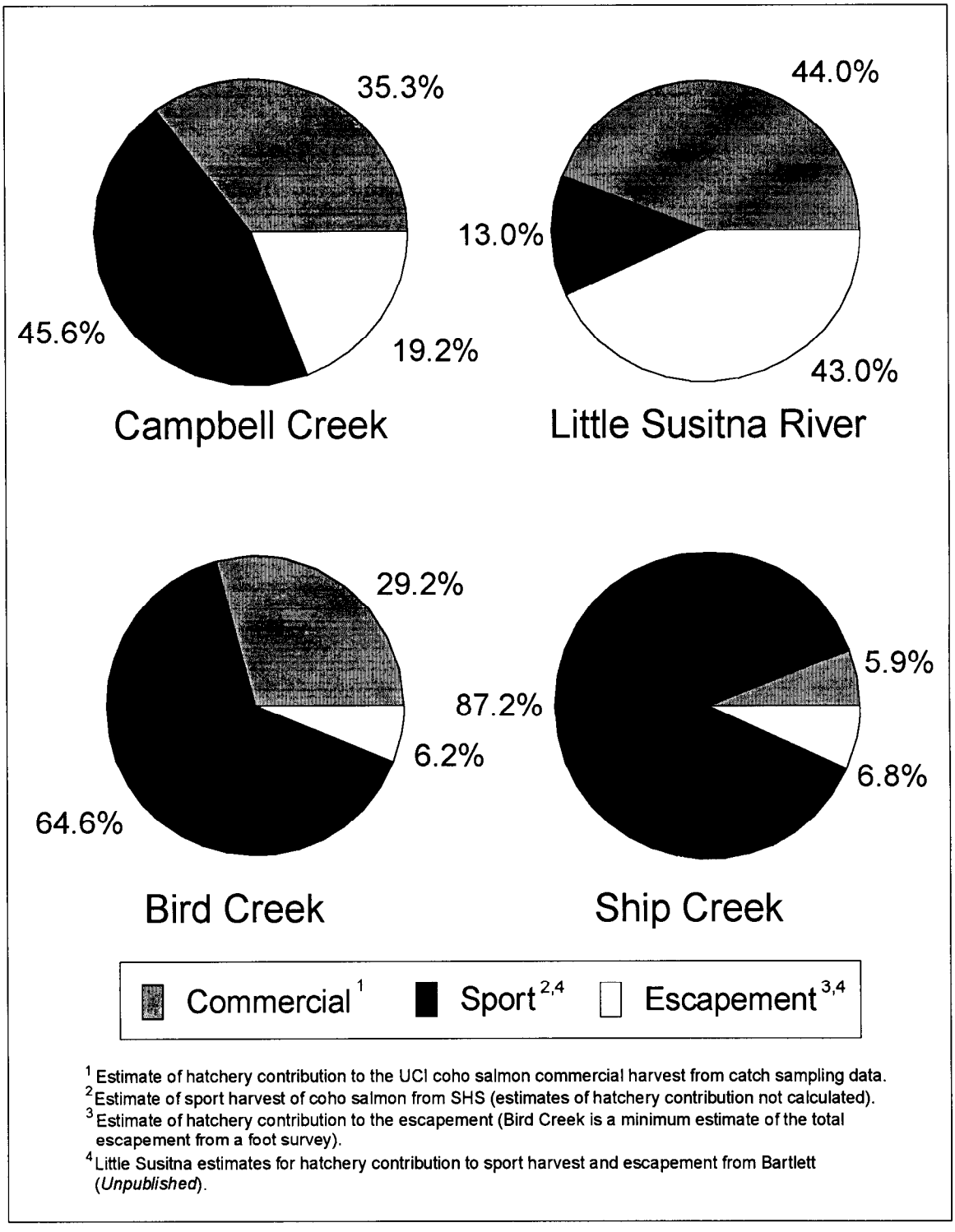
Nearly all of the samples collected from the commercial set net harvest from statistical areas 247-10 and 247-20 were mixed loads from these two areas. Many samples from statistical areas 247-70, 247-80, and 247-90 were also a

Table 4. Number of coded wire tagged coho salmon recovered from the escapement by release site in Upper Cook Inlet, 1993.

RELEASE SITE	RECOVERY SITE[a]				Total Recoveries
	Ship Creek	Campbell Creek	Little Susitna	Fish Creek	
Ship Creek	30				30
Campbell Creek	2	143			145
Little Susitna River[b]	1		156		157
Fish Creek				7	7
Homer Spit	2				2
Total	35	143	156	7	341

[a] No ad-clipped fish were observed in Jim Creek coho escapement (Bartlett *Unpublished*).

[b] Bartlett 1994.



[1] Estimate of hatchery contribution to the UCI coho salmon commercial harvest from catch sampling data.
[2] Estimate of sport harvest of coho salmon from SHS (estimates of hatchery contribution not calculated).
[3] Estimate of hatchery contribution to the escapement (Bird Creek is a minimum estimate of the total escapement from a foot survey).
[4] Little Susitna estimates for hatchery contribution to sport harvest and escapement from Bartlett (*Unpublished*).

Figure 3. Distribution of coho salmon returns among commercial and sport fisheries and the escapement in three stocked streams.

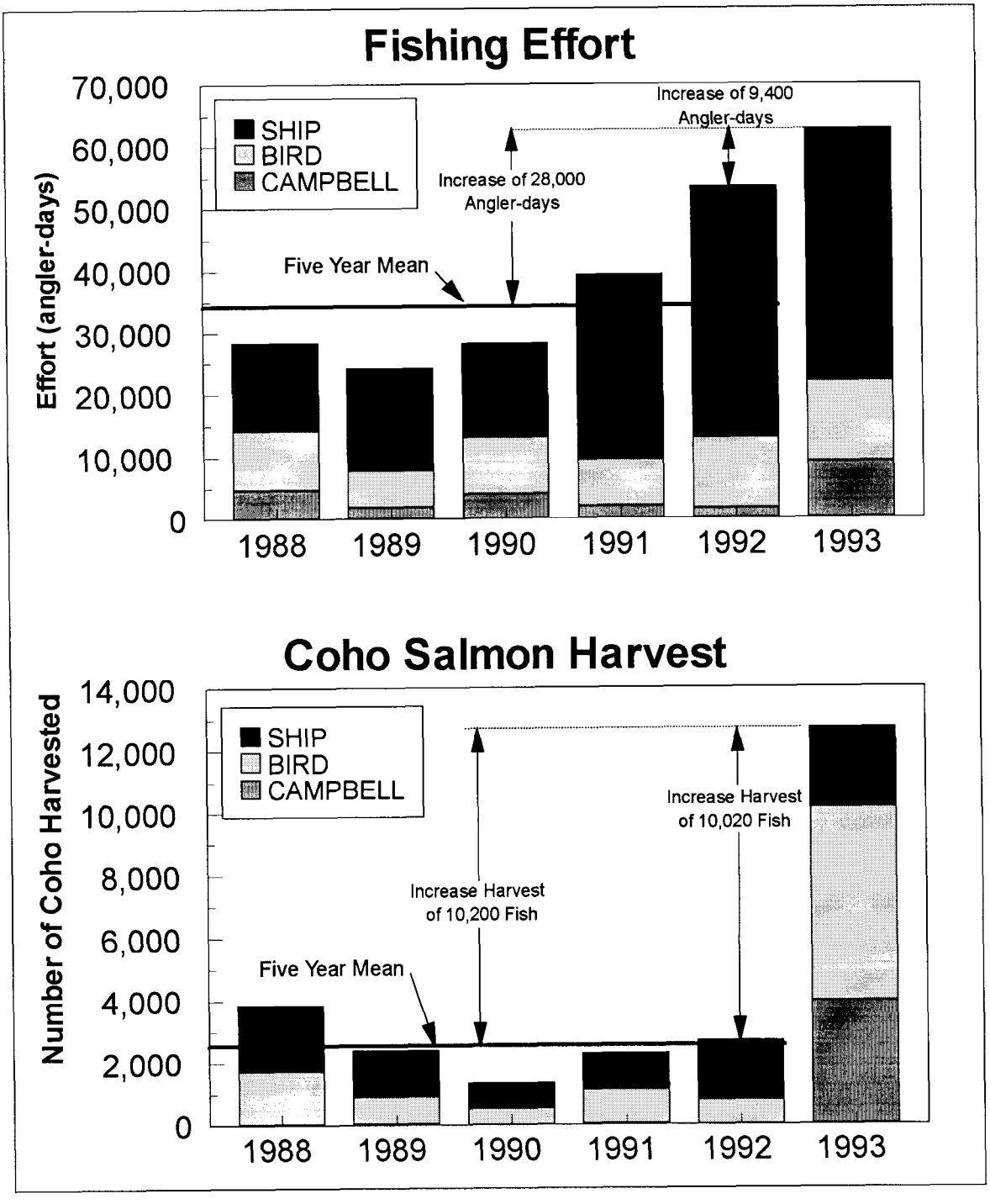


Figure 4. Sport harvest and effort from 1988 to 1993 in Anchorage urban streams (Campbell, Ship and Bird creeks) stocked with coho salmon (Mills 1989-1994).

Table 5. Total harvest of coho salmon in commercial fisheries of Upper Cook Inlet in 1993 except for set net fisheries in statistical areas 245 and 246.

Statistical		Dates		Dates							
Gear	Area	Begin	End	6/25-7/11	7/12-7/21	7/22-7/28	7/29-8/04	8/05-8/11	8/12-8/18	8/19-9/15	Total
Drift net	244 & 245[a]	6/25	9/03	1,300	23,119	49,548	40,379	4,878	1,382	1,179	121,785
Set net	244-21	7/02	8/13	23	218	270	1,109	1,305	828		3,753
	22	7/02	8/13	11	465	620	1,512	1,765	759		5,132
	30	7/05	8/13	9	816	3,063	6,857	1,967	608		13,320
	40	7/05	8/13	12	1,573	5,821	10,436	2,190	838		20,870
	Total			55	3,072	9,774	19,914	7,227	3,033		43,075
	247-10-20[b]	7/05	8/30	117	4,343	3,902	6,565	4,206	3,564	1	22,698
	30	7/02	8/16	40	7,898	8,276	18,635	4,278	434		39,561
	41	7/16	8/16		357	961	4,196	2,018	473		8,005
	42	7/12	8/16		176	196	2,912	1,838	795		5,917
	43	7/02	9/13	557	474	1,199	2,623	2,820	1,606	900	10,179
	50	7/18	7/25		175	656					831
	70-80-90[c]	7/02	9/13	10	494	1,225	1,710	2,091	4,207	9,330	19,067
	Total			724	13,917	16,415	36,641	17,251	11,079	10,231	106,258
Grand Total											271,118

[a] Combination of statistical areas 244-50, 244-60, 244-70, 245-70, 245-80, and 245-90.

[b] Combination of statistical areas 247-10 and 247-20.

[c] Combination of statistical areas 247-70, 247-80, and 247-90.

Table 6. Harvest of coho salmon from sampled commercial fisheries of Upper Cook Inlet in 1993.

Gear	Statistical area	Dates Begin	Dates End	Dates 7/12–7/21	7/22–7/28	7/29–8/04	8/05–8/11	8/12–8/18	8/19–9/15	Total
Drift net	244 & 245[a]	7/12	8/09	23,119	49,548	40,379	4,878			117,924
Set net	244-21	7/23	8/13		270	1,109	1,305	828		3,512
	22	7/23	8/13		620	1,512	1,765	759		4,656
	30	7/23	8/13		2,830	6,857	1,967	608		12,262
	40	7/23	8/13		5,439	10,436	2,190	838		18,903
	Total				9,159	19,914	7,227	3,033		39,333
	247-10-20[b]	7/19	8/16	1,822	3,902	6,565	4,206	3,564		20,059
	30[c]									0
	41	7/16	8/16	357	961	4,196	2,018	473		8,005
	42	7/16	8/13	174	196	2,912	1,838	667		5,787
	43	7/16	8/20	467	1,199	2,623	2,820	1,606	159	8,874
	50	7/18	7/18	101						101
	70-80-90[d]	7/16	9/13	481	1,225	1,710	2,091	4,207	9,330	19,044
	Total			3,402	7,483	18,006	12,973	10,517	9,489	61,870
Grand Total										219,127

[a] Combination of statistical areas 244-50, 244-60, 244-70, 245-70, 245-80, and 245-90.

[b] Combination of statistical areas 247-10 and 247-20.

[c] No coho salmon sampled from those harvested in statistical area 247-30.

[d] Combination of statistical areas 247-70, 247-80, and 247-90.

mixture from these three statistical areas. Other samples that were recorded as pure loads from one of the three statistical areas were also likely a mixture of fish harvested from the three statistical areas. Therefore, samples and harvest data from 247-10 and 247-20 were pooled together and those from 247-70, 247-80, and 247-90 were pooled together. Statistical areas from the Central District eastside set net fishery were not pooled because precision of the estimates did not improve appreciably when the areas were combined. Likewise, pooling data into weeks did not generally improve precision, especially in the Central District fisheries. Therefore, estimates of harvest of marked groups were stratified by statistical area, except those when the data were pooled because samples represented a mixture of fish harvested from different statistical areas, and by date.

The majority of the UCI coho harvest was taken in the Central District drift net fishery, followed by the Northern District set net fishery (Figure 5). Similarly, most of the hatchery-produced coho salmon were recovered in the Central District drift net and Northern District set net fisheries (Table 7, Figure 5). Overall, hatchery stocked coho salmon contributed 7.7% to the UCI coho salmon harvest sampled (Figure 6). When estimated by fishery, 7.6% of the sampled harvest of the Central District drift net fishery, 4.5% of the Central District set net fishery, and 10% of the Northern District set net fishery was composed of hatchery-produced fish (Figures 7, 8, and 9, respectively). The largest contributors to the commercial harvest were coho salmon stocked in three streams in the Anchorage urban area (Bird, Campbell, and Ship creeks) and the 1992 smolt releases into the Little Susitna River. The returns to the Little Susitna River composed over 50% of the hatchery returns in all of the fisheries. Coho salmon stocked into Bird and Campbell creeks provided nearly equal numbers of fish to each fishery. Relatively few coho salmon stocked into Ship Creek were harvested by the set net fisheries and no tags were recovered from the drift net fishery. Coho salmon from Ship Creek appeared later in the harvest than those stocked into Bird and Campbell creeks. Fish released into Ship Creek were from a different brood stock and may have a later run timing than those stocked into Bird and Campbell creeks.

DISCUSSION

Sport Fishery

The measure of success of the coho salmon stocking program is an increase in angler effort and harvest. The targeted increase in harvest of 10,000 fish was achieved, with a 10,020 fish increase over 1992 and a 10,200 fish increase over the 5-year mean. The estimated harvest is species specific so this increase is easily quantified. The ultimate measure of success, however, is the increase in angler effort. The Statewide Harvest Survey estimates angling effort for all species combined. Increased angler effort for a specific species is not easily quantified and may be masked or exaggerated by fluctuations in effort of other fisheries. The targeted increase in angler effort of 20,000 angler-days was achieved when compared to the 5-year mean, but there was only a 9,400 angler-day increase over the previous year. The true increase in angler effort for coho salmon may be masked by the continually increasing popularity of the chinook salmon fishery in Ship Creek. This fishery has grown dramatically in recent years and is included in the estimate of angler effort. In addition, a weakness of using the Statewide Harvest

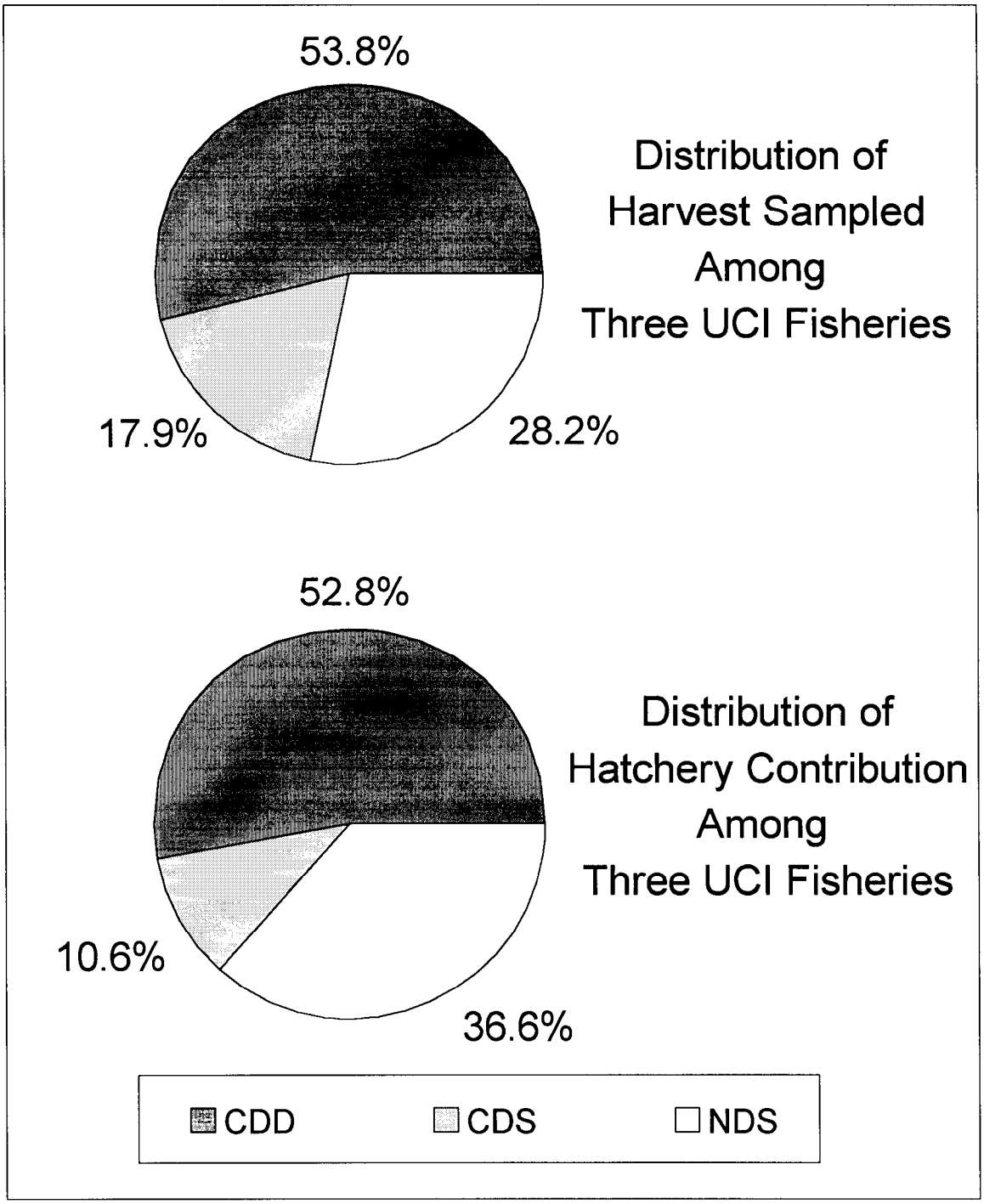


Figure 5. Distribution of coho salmon harvest and hatchery contribution among three UCI fisheries, Central District drift net (CDD), Central District set net (CDS), and Northern District set net (NDS), 1993.

Table 7. Estimates of harvest (n1) and variance [V(n1)] by release site of stocked coho salmon in the commercial fishery in Upper Cook Inlet, 1993.

Release Site	Gear	Statistical area	Dates 7/12-7/21 n1	7/12-7/21 V(n1)	7/22-7/28 n1	7/22-7/28 V(n1)	7/29-8/04 n1	7/29-8/04 V(n1)	8/05-8/11 n1	8/05-8/11 V(n1)	8/12-8/18 n1	8/12-8/18 V(n1)	8/19-9/15 n1	8/19-9/15 V(n1)	Total n1	Total V(n1)
Bird Creek (1992 smolt)	Drift net	244 & 245	183	1,169	633	5,629	687	5,018	49	558					1,552	12,374
	Set Net	244-21							8	54					8	54
		22							41	518					41	518
		30			10	83	14	80							24	163
		40			74	722	176	2,531	7	20					257	3,273
		247-10-20					26	159	16	155	4	14			46	328
		41	6	28	21	204	24	125	23	249	13	32			87	638
		42					40	151	32	140					72	291
		43	4	15	39	86	56	154	84	230	106	173	6	10	295	668
		70-80-90	4	11	11	108	110	710	122	3,043	114	666	60	171	421	4,709
Campbell Creek (1992 smolt)	Drift net	244 & 245	120	804	748	6,349	633	4,278	68	891					1,569	12,322
	Set Net	244-21							15	102					15	102
		22					8	56							8	56
		30			19	156	41	295							60	451
		40			28	132	173	1,924	29	94					230	2,150
		247-10-20			8	63	44	242	73	704	8	26			133	1,035
		41			10	97	84	387	33	325	16	37			143	846
		42	5	7			80	274	68	265	31	87			184	633
		43	8	27	44	94	169	701	120	283	121	185	8	14	470	1,304
		70-80-90					82	529	48	1,011	79	509	30	76	239	2,125
Ship Creek (1992 smolt)	Set Net	244-30							12	124					12	124
		247-10-20									9	17			9	17
		43							2	3	3	3			5	6
		70-80-90					2	4			6	6	141	128	149	138
Cottonwood Creek (1992 smolt)	Drift net	244 & 245			7	44									7	44
	Set Net	247- 41									2	3			2	3
		42							4	10					4	10
		43					11	32							11	32
		70-80-90					2	3	3	5			2	1	7	9
Fish Creek (1992 smolt)	Drift net	244 & 245					11	48							11	48
	Set Net	247- 41									2	3			2	3
		42					6	8	4	11	3	5			13	24
		43					2	2	4	5	3	2			9	9
		70-80-90					2	3							2	3

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Table 7. (Page 2 of 3).

Release Site	Gear	Statistical area	Dates 7/12–7/21 n1	7/12–7/21 V(n1)	7/22–7/28 n1	7/22–7/28 V(n1)	7/29–8/04 n1	7/29–8/04 V(n1)	8/05–8/11 n1	8/05–8/11 V(n1)	8/12–8/18 n1	8/12–8/18 V(n1)	8/19–9/15 n1	8/19–9/15 V(n1)	Total n1	Total V(n1)
Meadow Creek (1990 fingerling)	Set net	244-40					64	4,032							64	4,032
		247-42							82	3,274					82	3,274
		43									89	2,052			89	2,052
		70-80-90											20	375	20	375
Wasilla Creek (1992 smolt)	Drift net	244 & 245			8	55	12	57	9	70					29	182
	Set Net	244-40					16	113							16	113
		247- 41					19	58							19	58
		42							3	8					3	8
		43					4	4	5	8	10	14			19	26
		70-80-90									2	2	3	5	5	7
Houston (1992 smolt)	Drift net	244 & 245	136	3,625	833	24,304	973	23,272	63	3,857					2,005	55,058
	Set net	244-21					24	559							24	559
		22					22	455							22	455
		30					44	912							44	912
		40					87	2,642	105	1,787					192	4,429
		247-10-20			81	2,092	72	1,313	142	4,664	27	326			322	8,395
		41			33	1,059	140	2,320	173	5,811	11	103			357	9,293
		42					191	2,474	143	2,136	50	566			384	5,176
		43			70	633	79	1,148	113	1,064	78	634			340	3,479
		50	21	417											21	417
		70-80-90			34	1,112	11	110			9	74	9	65	63	1,361
Nancy Lake (1992 smolt)	Drift net	244 & 245	465	11,151	1,149	36,153	1,484	37,076	81	3,166					3,179	87,546
	Set net	244-22					50	1,195	50	2,446					100	3,641
		30			96	2,967	68	1,461	55	2,981					219	7,409
		40			58	1,798	262	7,605	55	947					375	10,350
		247-10-20	17	262	57	1,540	69	1,630	176	5,478					319	8,910
		41	32	477	104	3,480	150	2,657	143	5,015	34	341			463	11,970
		42					251	3,377	67	1,079	13	159			331	4,615
		43			105	1,001	134	2,866	135	1,403	48	462			422	5,732
		70-80-90			36	1,226	12	122	28	357	92	2,157	25	290	193	4,152

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Table 7. (Page 3 of 3).

Release Site	Gear	Statistical area	Dates 7/12-7/21 n1	7/12-7/21 V(n1)	7/22-7/28 n1	7/22-7/28 V(n1)	7/29-8/04 n1	7/29-8/04 V(n1)	8/05-8/11 n1	8/05-8/11 V(n1)	8/12-8/18 n1	8/12-8/18 V(n1)	8/19-9/15 n1	8/19-9/15 V(n1)	Total n1	Total V(n1)
Nancy Lake[a] (1990 fingerling)	Drift net	244 & 245	18	290	20	365	18	290	27	699					83	1,644
	Set net	244-40					36	694							36	694
		247-10-20					18	302							18	302
		41					36	413	45	962	7	41			88	1,416
		42					13	154	42	416					55	570
		43			7	43			23	150	6	25	6	32	42	250
		70-80-90					8	52			6	34			14	86
Nancy Lake[b] (1990 fingerling)	Drift net	244 & 245	70	1,556	174	4,990	223	5,294							467	11,840
	Set net	244-40			18	304	18	294							36	598
		247-41					49	763	32	978					81	1,741
		42					28	402	49	772	12	142			89	1,316
		43					17	126	10	85					27	211
		70-80-90					11	108							11	108
Nancy Lake[c] (1991 smolt)	Drift net	244 & 245					20	373							20	373
Little Susitna River Total[d]			617	15,932	2,654	77,365	4,123	93,194	1,529	42,191	362	4,822	34	274	9,375	233,269
Grand Total			1,089	19,839	4,535	96,889	7,106	124,437	2,712	58,143	1,014	8,900	310	1,167	16,885	308,737

[a] Fingerling released into Nancy Lake in 1990 with tag code 1301010405.

[b] Fingerling released into Nancy Lake in 1990 with tag code 1301010406.

[c] Smolt released into Nancy Lake in 1991.

[d] Total for Little Susitna includes only the 1992 smolt releases.

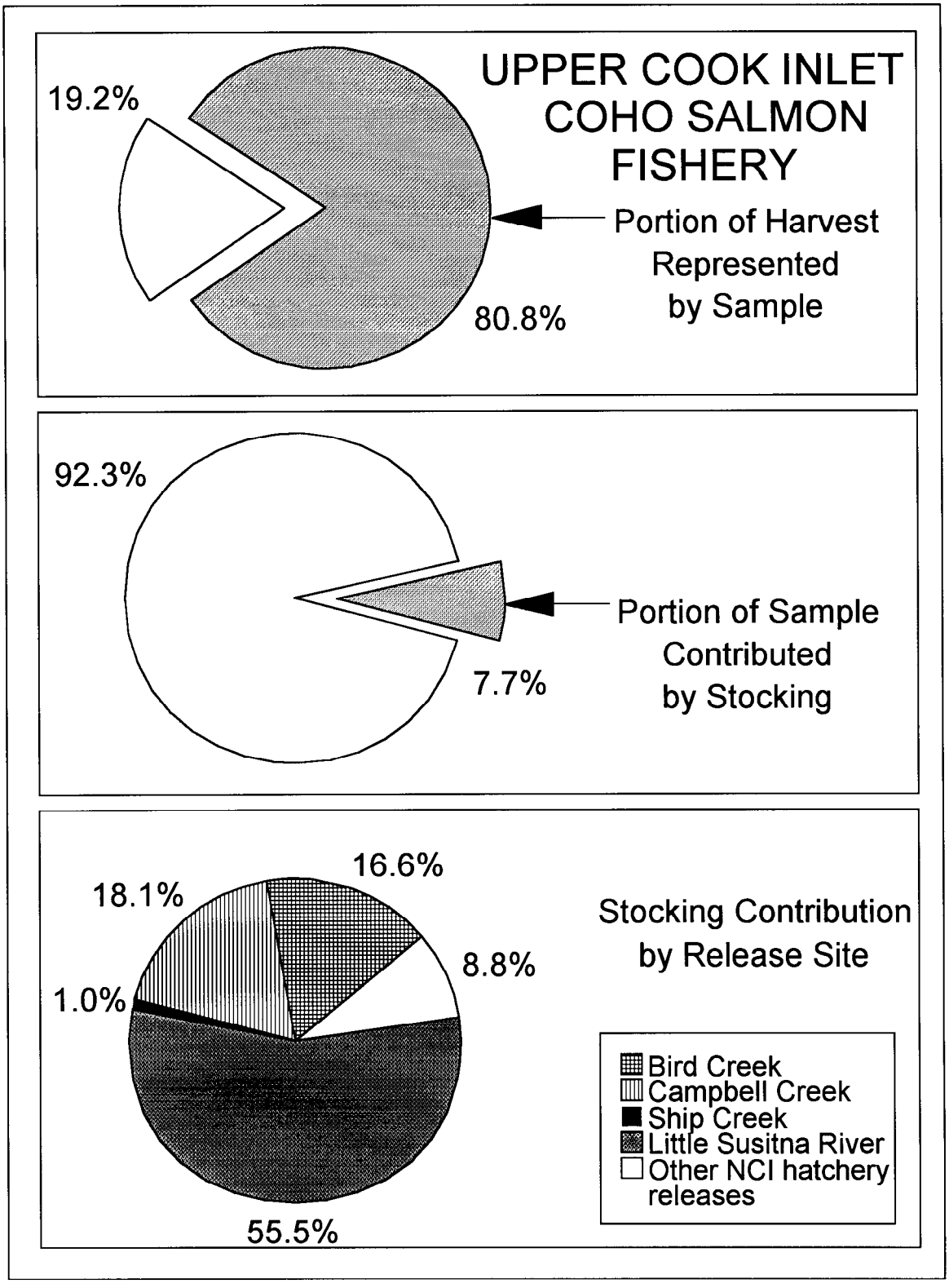

Figure 6. Portion of Upper Cook Inlet coho salmon commercial harvest represented by 1993 sampling efforts, and contribution of hatchery fish to that sample.

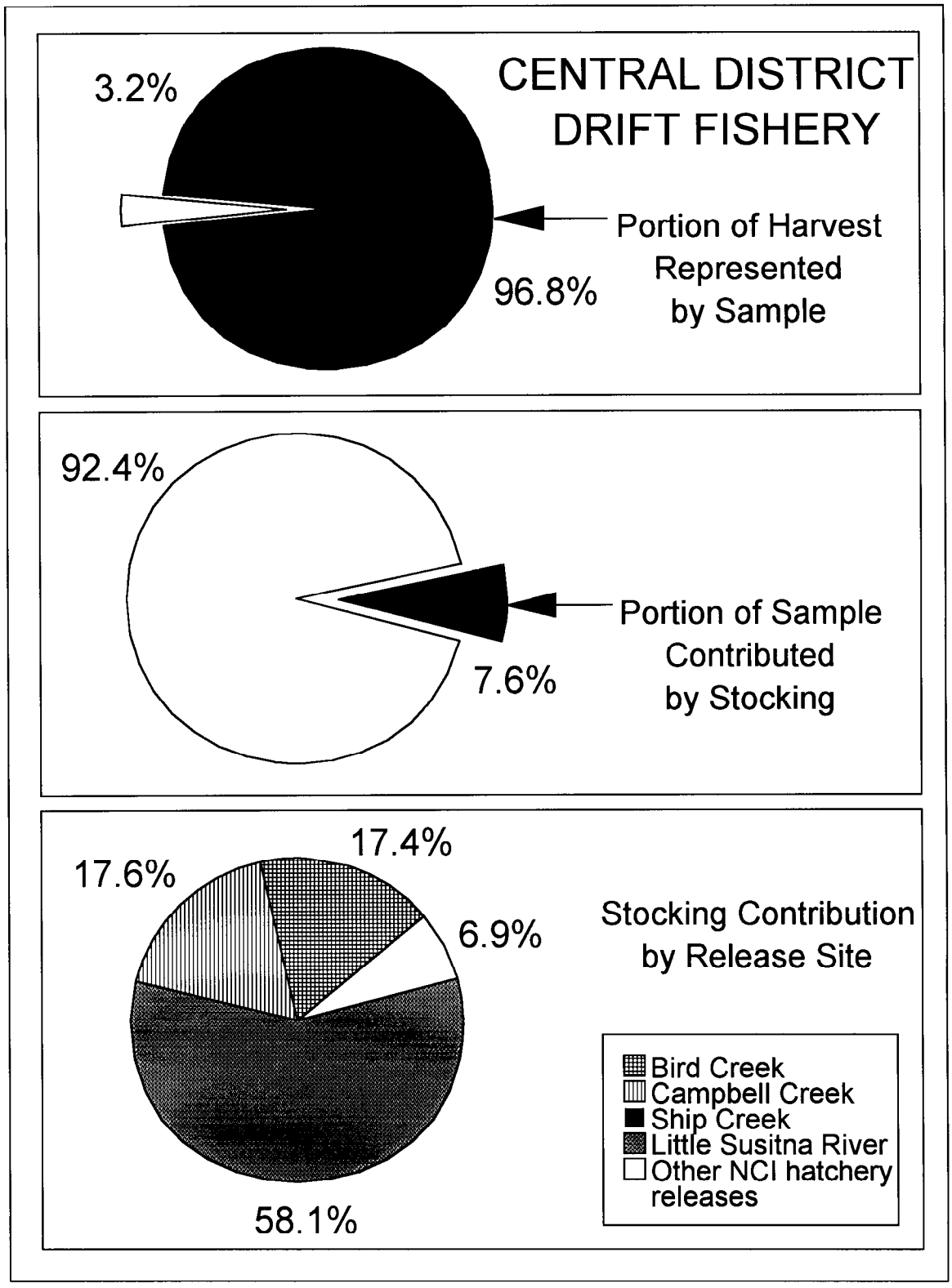

Figure 7. Portion of Central District drift, coho salmon commercial harvest represented by 1993 sampling efforts, and contribution of hatchery fish to that sample.

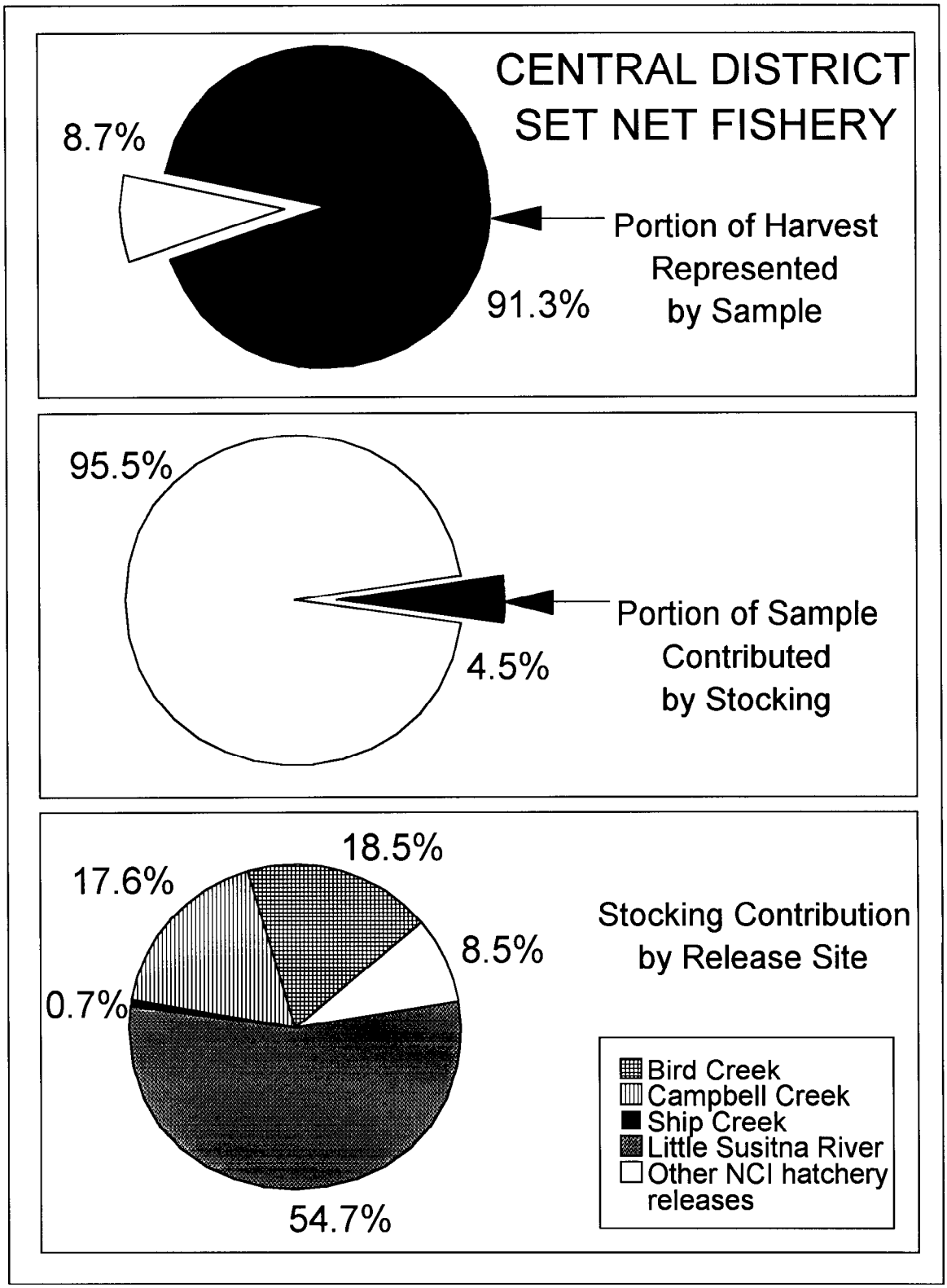

Figure 8. Portion of Central District set net coho salmon commercial harvest represented by 1993 sampling efforts, and contribution of hatchery fish to that sample.

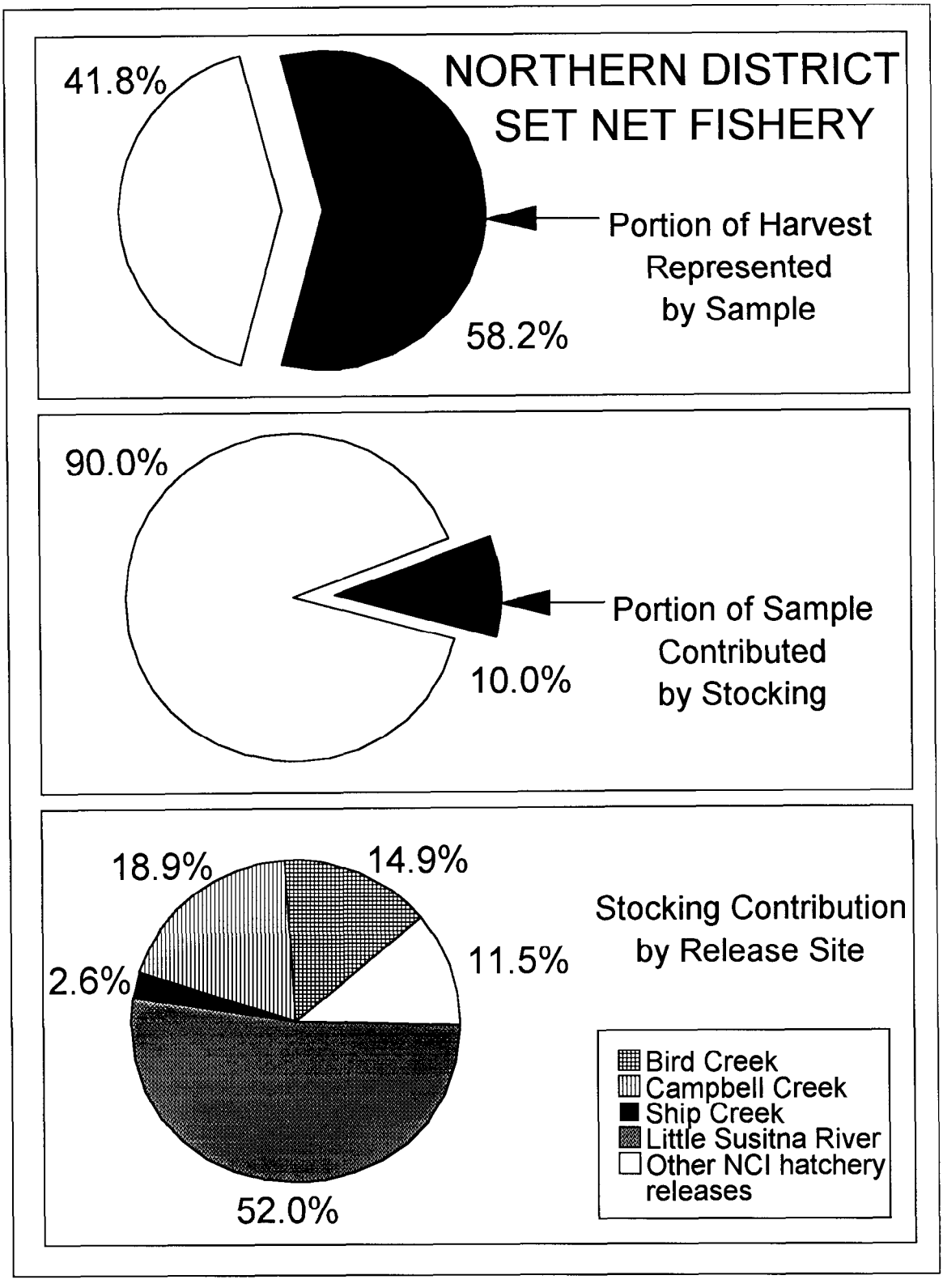

Figure 9. Portion of Northern District set net, coho salmon commercial harvest represented by 1993 sampling efforts, and contribution of hatchery fish to that sample.

Survey is that the survey targets licensed anglers. Urban creeks, especially Campbell Creek, are fished primarily by young anglers who are not required to purchase a license. Thus, these estimates of harvest and effort are considered minimal estimates. We believe results presented in this report and field observations of the sport fisheries indicate that the urban coho salmon stocking program succeeded in 1993.

Fish movements and best times for angling were different among the systems. At Campbell Creek, fish stayed in Campbell Lake during low water and moved into the fishery when water level increased after heavy rainfalls. The fisheries in Bird and Ship creeks, being essentially intertidal, were more closely related to the tides. Greatest success was during the 2 to 3 hours before and after high tides. This information should be considered in designing future sport sampling schedules.

Escapement

The biological escapement goal (BEG) of 200 coho salmon was met on both Ship and Campbell creeks. Although no coho salmon were observed jumping over the dam at Ship Creek during the highest tides at either day or night time, this concern still exists because hatchery staff have seen chinook salmon jump over the dam. In addition, hatchery staff have observed chinook salmon passing through the flow control gates of the dam when they are open. Since coho salmon may act similarly, this escapement count is considered a minimum rather than a total count.

The escapement count at Campbell Creek is also considered a minimum because the weir was removed before all coho salmon passed the weir. This minimum escapement count exceeded the BEG by a factor of ten, indicating that returns from this stocking effort were more than adequate for supporting the fishery.

Straying

The straying of hatchery-reared coho salmon was tested because of concerns that hatchery fish may compete with wild stocks for spawning areas, and the potential of genetic changes from mixing of wild and stocked fish. Our results indicate that straying is not a major concern. No straying occurred in any of the systems except Ship Creek. The trap box at Ship Creek is located at the upper extent of the intertidal area. Salmon stay or mill in the mouths of non-natal systems (Sandercock 1991), thus the Campbell Creek fish captured in Ship Creek may not have been destined to enter Ship Creek to spawn.

Tag Loss

Tag loss was detected by the absence of coded wire tags in adipose clipped fish. Tag loss estimated from the escapement samples ranged from 12% to 26% while tag loss in these same groups ranged between 10%-17% at release (Peltz and Starkey 1993). Therefore, tag loss occurred primarily before the fish were released and tag loss after release was relatively low.

Commercial Catch Assessment

Catch sampling of the UCI coho salmon fishery in 1993 was conducted when 81% of the coho salmon harvest occurred. Technicians examined 38% of this harvest and nearly 3% of the fish examined had adipose clips. Estimates of the contribution of hatchery-produced fish to the UCI commercial fisheries indicated that nearly 8% of the harvest sampled was of hatchery origin.

The pattern of the commercial harvest was typical of previous years. Forty-five percent of the coho salmon harvest occurred in the Central District drift net fishery, 16% in the Central District eastside set net fishery, and 39% in the Northern District set net fishery. The majority of the hatchery stocked fish harvested by the UCI commercial fishery were taken in the Central District drift net fishery: 52% of the total commercial harvest of coho salmon stocked into Anchorage urban systems and 55% of the total commercial harvest of coho salmon stocked into the Little Susitna River. The Northern District set net fishery took 37% of the estimated total commercial harvest of coho salmon stocked into Anchorage urban systems and 34% of the estimated total commercial harvest of coho salmon stocked into the Little Susitna River. The Central District eastside set net fishery took only 11% of the total commercial harvest of coho salmon stocked into both the Anchorage urban systems and the Little Susitna River.

Some results from the estimates of the commercial harvest of hatchery-produced coho salmon should be noted. First, pooling data among statistical areas or days generally did not improve precision of the estimates of the Central District fisheries. In addition, incorporating covariance terms when summing estimated variances among release groups within strata did not reduce the variance estimates greatly. Estimates of harvest of marked cohorts within the statistical area/day strata are not independent, so the total variance estimate has an additional covariance component (Clark and Bernard 1987). The small reduction in total variance resulting from incorporation of the covariances terms occurred because the catch sampling program recovers a large number of tagged fish from each cohort and the Tag Lab loses few heads due to good quality control.

Our results justify continuation of the stocking program. The terminal and commercial assessment programs should continue to evaluate the stocking program and determine if the success of this first year continues. Recommendations for the future include better sampling of several statistical areas in the Northern District (i.e., 247-10, 247-20, 247-30, 247-70, 247-80, and 247-90). This could be accomplished by placing technicians aboard tenders more frequently, closely following buying patterns of processors inseason, maintaining good rapport with processors, and stationing technicians in Homer and Soldotna. These steps would improve our ability to sample pure loads of coho salmon harvested in these statistical areas. The escapement count at Campbell Creek could be improved by using a floating weir rather than the picket weir used in 1993. A floating weir should perform better with high water and associated debris loads which occur during August and September.

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LITERATURE CITED

Bartlett, L. D. 1994. Creel, escapement, and stock statistics for coho salmon on the Little Susitna River, Alaska, during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-29, Anchorage.

_____. *Unpublished*. Coho and sockeye salmon stock assessment studies in the Jim Creek drainage, Knik Arm, Alaska, during 1993. Alaska Department of Fish and Game, Division of Sport Fish, Palmer.

Carlon, J. 1992. Feasibility of capturing and marking juvenile coho salmon for stock assessment in the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 92-57, Anchorage.

Carlon, J. and J. J. Hasbrouck. *In prep*. Recovery and estimation of commercial harvest of coho salmon from the Kenai River in the Upper Cook Inlet fishery in 1993. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Clark, J. E. and D. R. Bernard. 1987. A compound multivariate binomial-hypergeometric distribution describing coded microwire tag recovery from commercial salmon catches in Southeastern Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 261. Juneau.

Meyer, S., D. V. Vincent-Lang, and D. McBride. *Unpublished*. Goal statement and study plan for the development of a stock assessment program for Upper Cook Inlet coho salmon stocks (1991). Alaska Department of Fish and Game, Division of Sport Fish, Anchorage.

Mills, M. J. 1979. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1978-1979, Project F-9-11, 20 (SW-I-A), Juneau.

_____. 1980. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1979-1980, Project F-9-12, 21 (SW-I-A), Juneau.

_____. 1981a. Alaska statewide sport fish harvest studies 1979 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22 (SW-I-A), Juneau.

_____. 1981b. Alaska statewide sport fish harvest studies 1980 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22 (SW-I-A) Juneau.

_____. 1982. Alaska statewide sport fish harvest studies 1981 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1981-1982, Project F-9-14, 23 (SW-I-A), Juneau.

_____. 1983. Alaska statewide sport fish harvest studies 1982 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project F-9-15, 24 (SW-I-A), Juneau.

_____. 1984. Alaska statewide sport fish harvest studies 1983 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1983-1984, Project F-9-16, 25 (SW-I-A), Juneau.

_____. 1985. Alaska statewide sport fish harvest studies 1984 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1984-1985, Project F-9-17, 26 (SW-I-A), Juneau.

_____. 1986. Alaska statewide sport fish harvest studies 1985 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1985-1986, Project F-10-1, 27 (RT-2), Juneau.

_____. 1987. Alaska statewide sport fisheries harvest report 1986. Alaska Department of Fish and Game, Fishery Data Series No. 2, Juneau.

_____. 1988. Alaska statewide sport fisheries harvest report 1987. Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau.

_____. 1989. Alaska statewide sport fisheries harvest report 1988. Alaska Department of Fish and Game, Fishery Data Series No. 122, Juneau.

_____. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage.

_____. 1991. Harvest, catch, and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage.

_____. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage.

_____. 1993. Harvest, catch, and participation in Alaska sport fisheries during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage.

_____. 1994. Harvest, catch, and participation in Alaska sport fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage.

Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). *In* C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press. Vancouver, B.C., Canada.

Peltz, L. and D. Starkey. 1993. Summary and synthesis of production, marking, and release data for coho and chinook salmon smolt releases into Upper Cook Inlet, Alaska, in 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-51. Anchorage.

APPENDIX A

Appendix A. Daily escapement counts of coho salmon from weirs on Campbell and Ship creeks, 1993.

DATE	Campbell Creek		Ship Creek	
	Total Coho	Adipose Clips	Total Coho	Adipose Clips
July 19	weir installed			
30			2	1
31			5	
August 1			2	
2			1	
3	1			
4				
5			1	
6			4	1
7				
8			3	
9			2	1
10	2		4	4
11	3		3	
12			6	
13	1		15	1
14	39	10	27	5
15			22	4
16	19	4	22	4
17			7	
18			9	1
19			1	
20			4	1
21	16	4	14	
22	91	19	6	
23	9	3	3	2
24			2	
25			2	
26	4	1	1	
27			2	1
28	2		3	
29	98	23	8	4
30	331	93	7	6
31	186	42	11	4
September 1	424	167	5	2
2	76	18	3	2
3	22	3	3	
4	50	12		
5	134	36	16	8
6	41	6	1	
7	98	31	44	18
8	33	9	5	2
9	51	11	3	2
10	94	25	12	11
11	12	3	2	2
12	142	33		
13	174	52	5	3

-continued-

Appendix A. (Page 2 of 2).

DATE	Campbell Creek		Ship Creek	
	Total Coho	Adipose Clips	Total Coho	Adipose Clips
14	160	48	3	1
15	63	20		
16	weir removed		18	6
17			13	6
18			3	3
19				
20				
21			3	3
22			2	2
23			2	1
24				
25			1	
26				
27				
28				
29			2	1
30			5	5
October 1				
2			4	2
3			2	2
4				
5			1	1
6			1	
7			2	1
8				
9			2	1
10				
11			1	
12			1	1
13				
14				
15			5	1
16				
17				
18				
19			2	1
20				
21			3	
22				
23				
24				
25				
26				
27			2	1
28				
29			2	1
30				
31				
November 1			4	2
TOTAL	2,376	673	382	128